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REMARKS

Claims 19-45 were examined. Claims 1-18 were canceled in the Preliminary Amendment filed January 19, 2001. Claims 30-31 are amended. Claims 35-45 are allowed. Examination and reconsideration of all pending claims are respectfully requested.

Objection to the Specification

The Examiner objected to the specification on the basis that the current status of each of the patent applications was not provided. Per the Examiner's request, Applicants have amended the claim of priority to list the current status of each of the patent applications. No new matter has been added.

Applicants have further amended the specification to correct typographical errors. No new matter has been added.

Pending Claims

Claims 19-45 are pending. In the Office Action of May 22, 2002, however, the Examiner rejected claims 1-28 and 30-34. It should be noted that Applicants had previously canceled claims 1-18 in the Preliminary Amendment filed with the Continued Prosecution Application on January 19, 2001. The cancellation of claims 1-18 was reiterated in the Amendment filed on December 13, 2001. Thus, the only pending claims in the present application should be claims 19-45.

Allowable Subject Matter

Applicants thank the Examiner for the indication that claims 35-45 are allowed.

The Examiner further indicated that claim 29 would be allowable if rewritten into independent form including all of the limitations of the base claim and intervening claims. Applicants, however, presently decline to so amend claim 29 and instead respectfully request reconsideration and withdrawal of the rejection of independent claims 27 in view of the remarks below.

Rejection of Claims Under 35 U.S.C. § 102(b)

Claims 1-28 and 30-34 are rejected under 35 U.S.C. § 102(b) as allegedly being anticipated by U.S. Patent No. 4,278,920 to Ruoff, Jr. ("Ruoff"). Such a rejection is overcome in part and traversed in part as follows.

A. Independent Claim 19

Independent claim 19 recites a computer mediated control system for use in a force feedback system. The force feedback system includes at least one actuator and at least one position sensor. The control system comprises a memory storing at least one force feedback effect. The force feedback effect provides forces to be output to a user of said force feedback system. The system also includes a computer mediated controller coupled to the actuator(s) and to the position sensor(s). The computer mediated controller receives input information through a communication port of the computer mediated controller and decodes commands from the input information. Force values are read from the communication port. Output data is output on the communication port and includes position data from the position sensor(s). Installed force feedback effect(s) are determined to contribute to the output of the force feedback system. The installed force feedback effect is processed to determine a force contribution from the force feedback effect, and a force feedback value is output based on the determined force contribution to cause a force based on the force feedback value to be output by the actuator to the user of said force feedback system. The cited art does not describe or suggest such a system.

In contrast, Ruoff describes a method and device for generating a control program for a position system by manually exerting forces on the positional member to direct it along the desired path, employing force feedback to modify the drive control signals to achieve the desired motion and recording the resulting position or motion rate transducer signals. The command signals for the servos are derived from the force feedback signals and the positional transducers. The force feedback signals effectively act to modify the existing command signals to cause the motion of the controlled axes in such a manner as to decrease the force exerted between the positional member and external instrumentalities. (*See* Ruoff at col. 2, lines 32-55).

Claim 19 is allowable over Ruoff for at least two reasons. First, Ruoff does not store installed force feedback effects. Instead, Ruoff describes generating the force feedback effect depending on the motions of the manipulator when moved by the user. Such force feedback effects are not pre installed force feedback effects. Second, Ruoff does not provide forces to be output to a user. Instead, the force feedback, as described in Ruoff, is to control the manipulator for duplicating the original motion of the user. When the force feedback is applied to the positional member, the user is not holding or otherwise using the positional member.

For the above reasons, independent claim 19 is allowable over the cited art.

B. Independent Claim 27

Independent claim 27 recites a force feedback device. The device comprises a user manipulatable member that has at least one degree of freedom of motion and is manipulatable by a user physically contacting the member. At least one actuator outputs forces to the user. At least one position sensor determines a position of the user manipulatable member in at least one degree of freedom. A computer mediated controller is coupled to the actuator and to the at least one position sensor. The controller receives input information through a communication port of the computer mediated controller and decodes commands from the input information. The controller reads force values from the communication port and outputs output data on the communication port. The output data includes position data from the position sensor. The controller determines at least one installed force feedback effect to contribute to the output of the force feedback system. The controller processes the installed force feedback effect to determine a force contribution from the installed force feedback effect and outputs a force feedback value based on the determined force contribution to cause a force based on the force feedback value to be output by the actuator to the user of the force feedback system. Such a device is not described or suggested by the cited reference.

Similar to above, independent claim 27 is allowable over Ruoff for at least two reasons. First, Ruoff does not describe or suggest having installed force feedback

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effects that are to output to the user. Instead, Ruoff describes generating the force feedback effect depending on the motions of the manipulator when moved by the user. Such force feedback effects are not installed force feedback effects. Second, Ruoff does not provide forces to be output to a user. Instead, the force feedback, as described in Ruoff, is to control the positional member for duplicating the motion of the user. When the force feedback is applied to the positional member, the user is not holding or otherwise using the positional member.

For the above reasons, independent claim 27 as originally filed, is allowable over the cited art.

Dependent Claims

In addition to relying on allowable independent claims, dependent claims 20-26, 28, and 30-34 are allowable as they further recite novel features not described or suggested by the cited art. For example, claims 20 and 33 recite that the force feedback effect is one of a detent effect, a wall effect, and a spring effect. The Examiner has not shown where the cited art describes or suggest such effects. For the above reasons, dependent claims 20-26, 28, and 30-34 are also allowable.

CONCLUSION

In view of the foregoing, Applicants believe all claims now pending in this Application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 415-576-0200.

Respectfully submitted,

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APPENDIX A: VERSION OF SPECIFICATION WITH MARKINGS TO SHOW CHANGES MADE

Please replace the paragraph starting on page 1, line 2 with the following:

This is a continuation of U.S. Patent Application No. 09/333,613, filed June 15, 1999, now U.S. Patent No. 6,104,158, which is a continuation of Application No. 09/185,301, filed November 3, 1998, now abandoned, which is a continuation of Application No. 08/854,375, filed May 12, 1997, now U.S. Patent No. 5,831,408, which is a continuation of Application No. 08/543,606, filed October 16, 1995, now U.S. Patent No. 5,629,594, which is a continuation-in-part of U.S. patent application No. 08/257,070, filed June 9, 1994, now U.S. Patent 5,459,382, which is a divisional application of U.S. Application No. 07/984,324, filed December 2, 1992, now U.S. Patent No. 5,389,865.

Please replace the paragraph starting on page 3, line 24 with the following:

Further, by reacting to remote forces present on a slave device, the prior art devices lack the capability of creating a three-dimensional tactile virtual reality environment whereby a user's actions and reactions are related to a simulated world such as simulation of driving or flying functions, simulation of molecular force interactions, or simulations of surgical procedures. U.S. Patent No. 5,044,956 to Behensky et al. discloses a system whereby a steering wheel is used to input positions to a simulation which in turns **[turn]** actuates the wheel in response to simulated artifacts. This system does not disclose or anticipate the simulation and coordination of the six-degrees of freedom required for the arbitrary positioning and orientation of solid objects. Similarly, prior art devices which simulate virtual reality by visual feedback to a user are not capable of accepting tactile inputs and providing tactile force feedback.

Please replace the paragraph starting on page 4, line 12 with the following:

The present invention solves the problems of the prior art by providing a method and system for providing a tactile virtual reality in response to user position and orientation. The present invention further provides a universal device whose kinematics

do not necessarily replicate any particular device it might control or simulate. A computer mediated control system is provided which transforms forces, torques, displacements, velocities, and accelerations measured by a simulated environment and applies them to the hand controller or vice **[visa versa]**. The present invention can effect and control the superposition of translational displacement with force application and angular displacement with torque, thus providing arbitrary, programmed application of forces, torques, and displacements to the user in any direction. This allows the device to be controlled by, and to control, external simulations or models as well as physical remote devices. The invention can also locally simulate virtual force fields generated from interaction with virtual surfaces and/or boundaries, can provide software programmed position, velocity, force, and acceleration limit stops, and can dynamically shift, rotate, or scale these virtual objects.

Please replace the paragraph starting on page 6, line 24 with the following:

FIGURE 6a presents a top view of the X-Portion **[X portion]** of the X-Y table of an embodiment of the manipulator of the present invention;

Please replace the paragraph starting on page 7, line 27 with the following:

FIGURE 11b presents a top view of the roll-stage **[roll stage]** of the manipulator of an embodiment of the present invention;

Please replace the paragraph starting on page 13, line 14 with the following:

Referring to Figure 10, the pitch stage is shown. Figure 10a presents a front view of the pitch stage and Figure 10b present side view of the pitch stage. The pitch stage is comprised of the pitch motor 160, which is coupled to the pitch gearbox 162 affixed to the yaw-pitch bracket 150. The pitch gearbox includes **[which contains]** a pitch spur gear 166 coupled to the pitch motor pinion 168. The output shaft of the gearbox is affixed normal to the vertical arm of the pitch-roll gimbal bracket 170. The weight of the roll axis and the pitch-roll gimbal is compensated by using a constant force

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spring 172 with a spring spool 174. This does not provide perfect balance accept at the equilibrium position. However, the small centering force is easily overpowered by the pitch motor gear train and holding friction.

Please replace the paragraph starting on page 20, line 9 with the following:

If the interrupt routine determines that it is time to run the servo code, it first checks (in the overrun logic) to see if a previous call to the servo routines is still being processed (this is done via interlocking flags). If the last loop has not yet completed, i.e. there are to many commands or controls to <u>be</u> executed in the user programmed interrupt call-back period, an overrun is signaled and the new interrupt is rejected until the old one is fully completed, also servo calculations compensate time normalization based on the overrun information -- in effect, when overrun occurs, it is as though the clock interval has been doubled in duration.

Please replace the paragraph starting on page 21, line 15 with the following:

The force contributions to the <u>various axes</u> **[various axes]** are appropriately scaled and applied to a running sum of contributions (which are summed across multiple control function calls). When the control/command function lists are completed, the resulting final set of forces (or torques) become the values set into the output digital to analog interfaces.

Please replace the paragraph starting on page 22, line 29 with the following:

For cases where D is larger <u>than</u> **[that]** Rmax, the force contribution, Fin and Fout, are [0,0]. For cases where D is less than R, Fout is zero and Fin is computed as a force directed toward the center, Xc, Yc, from the current joint coordinates, X, Y. This computation is as follows:

APPENDIX B: VERSION OF CLAIMS WITH MARKINGS TO SHOW CHANGES MADE

30. (Amended) A force feedback device as recited in claim 27, further comprising a gear transmission provided between said member **[joystick]** and said plurality of actuators, said gear transmission transmitting said output forces from said actuators to said member.

31. (Amended) A force feedback device as recited in claim 27, wherein a memory is accessible to said **[software]** controller.

APPENDIX C: CLEAN VERSION OF ALL PENDING CLAIMS

1. ~~19~~. (As filed) A computer mediated control system for use in a force feedback system, said force feedback system including at least one actuator and at least one position sensor, said control system comprising:

a memory storing at least one force feedback effect, said at least one force feedback effect providing forces to be output to a user of said force feedback system; and

a computer mediated controller coupled to said at least one actuator and to said at least one position sensor, wherein said computer mediated controller

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receives input information through a communication port of said computer mediated controller and decodes commands from said input information,

reads force values from said communication port,

outputs output data on said communication port, said output data including position data from said at least one position sensor,

determines at least one installed force feedback effect to contribute to output of said force feedback system,

processes said stored force feedback effect to determine a force contribution from said force feedback effect, and

outputs a force feedback value based on said determined force contribution to cause a force based on said force feedback value to be output by said actuator to the user of said force feedback system.

2. ~~20~~. (As filed) A computer mediated control system as recited in claim 1 ~~19~~, wherein said force feedback effect is one of a detent effect, a wall effect, and a spring effect.

3. ~~21~~. (As filed) A computer mediated control system as recited in claim 1 ~~19~~, wherein said force feedback effect includes at least one parameter, and wherein

said at least one parameter is at least one of a stiffness parameter, a damping parameter, a force parameter, and a distance parameter.

4. ~~22~~. (As filed) A computer mediated control system as recited in claim 1 ~~19~~, wherein said force feedback value is a result of summing force contributions from a plurality of installed force feedback effects.

5. ~~23~~. (Previously amended) A computer mediated control system as recited in claim 1 ~~19~~, wherein pointers are provided by a user of said force feedback system to install desired force feedback effects to contribute to said output force feedback value.

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6. ~~24~~. (Previously amended) A computer mediated control system as recited in claim 1 ~~19~~, further comprising computing velocity from said position data received from said at least one position sensor and using said velocity in said determination of said force contribution.

7. ~~25~~. (Previously amended) A computer mediated control system as recited in claim 1 ~~19~~, wherein said force feedback effect contributes to said output force feedback value as a result of a user manipulatable member being moved by a user to enter a boundary of said force feedback effect as determined by said position data.

8. ~~26~~. (Previously amended) A computer mediated control system as recited in claim 7 ~~25~~, wherein said output data includes button press data from at least one button provided on said user manipulatable member of said force feedback system.

9. ~~27~~. (Previously amended) A force feedback device, comprising:

a user manipulatable member having at least one degree of freedom of motion and being manipulatable by a user physically contacting said member;

at least one actuator outputting forces to said user;

at least one position sensor for determining a position of said user manipulatable member in said at least one degree of freedom; and

a computer mediated controller coupled to said actuator and to said at least one position sensor, wherein said controller

receives input information through a communication port of said computer mediated controller and decodes commands from said input information,

reads force values from said communication port,

outputs output data on said communication port, said output data including position data from said position sensor,

determines at least one installed force feedback effect to contribute to output of said force feedback system,

processes said installed force feedback effect to determine a force contribution from said installed force feedback effect, and

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outputs a force feedback value based on said determined force contribution to cause a force based on said force feedback value to be output by said actuator to the user of said force feedback system.

10. ~~28~~. (As filed) A force feedback device as recited in claim 9 ~~27~~, wherein said user manipulatable member is a joystick.

11. ~~29~~. (As filed) A force feedback device as recited in claim 9 ~~27~~, further comprising a deadman switch for disabling said output forces when said user is not manipulating said member.

12. ~~30~~. (Amended) A force feedback device as recited in claim 9 ~~27~~, further comprising a gear transmission provided between said member and said plurality of actuators, said gear transmission transmitting said output forces from said actuators to said member.

13. ~~31~~. (Amended) A force feedback device as recited in claim 9 ~~27~~, wherein a memory is accessible to said controller.

~~32.~~ 14. (As filed) A force feedback device as recited in claim ~~31~~ 13, wherein said memory is non-volatile memory.

~~33.~~ 15. (As filed) A force feedback device as recited in claim ~~27~~ 9, wherein said force feedback effects include at least one of a detent, a wall, and a spring.

~~34.~~ 16. (As filed) A force feedback device as recited in claim ~~27~~ 9, wherein each of said force feedback effects includes at least one parameter, and wherein said at least one parameter is at least one of a stiffness parameter, a damping parameter, a force parameter, and a distance parameter.

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~~35.~~ 17. (Allowed) A method for providing output force from an actuator in a force feedback device, the method comprising:

outputting a maximum peak force from an actuator on a user manipulatable object of said force feedback device, wherein a user can manipulate said user manipulatable object in a degree of freedom, and wherein said maximum peak force is related to a maximum power that said actuator can utilize instantaneously; and

reducing said output of said maximum peak force to an output of a nominal peak force from said actuator when said power utilized by said actuator exceeds an average power level over a predetermined period of time, wherein said nominal peak force is related to a maximum power that said actuator can utilize in continuous steady-state operation.

~~36.~~ 18. (Allowed) A method as recited in claim ~~35~~ 17, wherein said maximum peak force is output only when said user initially moves said user manipulatable object into an object simulated by a computer system.

~~37.~~ 19. (Allowed) A method as recited in claim ~~35~~ 17, wherein said maximum peak force has about twice as great a magnitude as said nominal peak force.

20\. ~~38~~. (Allowed) A method as recited in claim ~~36~~ 17, wherein said nominal peak force is associated with an average current during operation of said actuator.

21\. ~~39~~. (Allowed) A method as recited in claim ~~36~~ 17, further comprising monitoring average power requirements of said actuator over time to determine when said power utilized by said actuator exceeds said average power level over said predetermined period of time.

22\. ~~40~~. (Allowed) A method as recited in claim ~~36~~ 17, wherein said predetermined period of time is about two seconds.

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23\. ~~41~~. (Allowed) A force feedback device that interfaces with a computer graphical simulation, said force feedback device comprising:

a user manipulatable object moveable by a user in at least one degree of freedom;

at least one sensor that detects a position or motion of said user manipulatable object in the at least one degree of freedom; and

at least one actuator outputting a force on the user manipulatable object, the at least one actuator outputting a maximum peak force on the user manipulatable object,

wherein the peak force is related to a maximum power that the at least one actuator can utilize instantaneously, and wherein the maximum peak force is reduced to a nominal peak force by the actuator when the power utilized by the actuator exceeds an average power level over a predetermined period of time, wherein the nominal peak force is related to a maximum power that the actuator can utilize in continuous steady-state operation.

24. ~~42~~. (Allowed) A force feedback device as recited in claim ~~41~~ 23, wherein the maximum peak force is output only when the user initially moves the user manipulatable object into an object simulated in the computer graphical simulation.

25. ~~43~~. (Allowed) A force feedback device as recited in claim ~~41~~ 23, wherein the maximum peak force has about twice as great a magnitude as the nominal peak force.

9 Period.

26. ~~44~~. (Allowed) A force feedback device as recited in claim ~~41~~ 23, wherein the predetermined period of time is about two seconds.

27. ~~45~~. (Allowed) A force feedback device as recited in claim ~~41~~ 23, wherein the user manipulatable object is a joystick.